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Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

CSA STANDARD M424 - ITERATION No. 8
FLAMEPROOF DIESEL-POWERED VEHICLES FOR USE IN GASSY UNDERGROUND COAL MINES

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Prepared as a working document for further development by the "CSA Technical Committee on Underground Diesel Equipment"

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MICROMEDIA

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1. Scope

1.1
This Standard describes the technical requirements and procedures necessary for the design, performance and testing of new or unused flameproof, diesel-powered, non-rail-bound, self-propelled vehicles for use in gaseous underground mines. The working environment of such mines is characterized by the presence of methane gas and of combustible dust.

1.2
The spontaneous ignition temperature of such combustible dust is limited to a minimum of 150°C (300°F), which value represents the maximum allowable vehicle surface temperature for the purposes of this standard.

1.3
This standard applies to vehicles of 45,000 kg (100,000 lb) mass or less, which are designed to operate on level ground at a maximum speed of 32.2 km/h (20 mph) or less.

1.4
Performance of the vehicle from standpoints such as brake performance, water scrubber functioning etc., shall be evaluated at a reference grade of 20% for the purposes of this standard unless specifically noted otherwise on the "Grade Certification Plate".

2. Definitions

Many terms are defined in the several standards referred to in this document, (see clause 3.1). Additional terms are defined below:

2.1 Explosion-related terms

Explosion-proof (flameproof) enclosure means an enclosure that is capable of withstanding, without damage, an explosion that may occur within it of a specified gas or vapour; and is capable of preventing ignition of a specified gas or vapour surrounding the enclosure that might be caused by sparks or flames from the explosion of the specified gas or vapour within the enclosure (synonymous with "Flameproof Enclosure" as defined in IEC Publication 79-1, Part 1).

Explosive gas mixture means a mixture of methane with air in which, after ignition, combustion spreads throughout the unconsumed mixture. The lean and rich limits of flammability of methane mixtures in atmospheric air are often quoted to be 4 to 15% methane by volume, respectively.

Flame arrester (flametrap) means a device for preventing passage of flame while permitting the flow of gas or vapour.

Intrinsic safety means elimination of the risk of explosion due to any spark or thermal effect produced either normally or by specified fault conditions in a circuit. Thus, the spark or thermal effect is incapable under prescribed test conditions of causing ignition of that mixture of methane-in-air most easily ignited by an open electric spark discharge.

Joint gap, width, path etc. - See CSA Standard C22.2 No. 30 "Explosion-Proof Enclosures for Use in Hazardous Locations", and IEC Standard 79-1 "Electrical Apparatus for Explosive Gas Atmospheres."

Spark arrester means a device for preventing the passage of incandescent particles while permitting the flow of gas or vapour.

2.2 **Emissions - related terms**

ACGIH-TLV means American Conference of Governmental and Industrial Hygienists - Threshold Limit Values. Threshold limit values (TLVs) refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. The time-weighted average TLVs, (TLV-TWA) are those concentrations that apply to a normal 8-hour workday or 40-hour work week. The threshold limit value ceiling (TLV-C) is the concentration that should not be exceeded even instantaneously (NO_2 is so categorized).

Exhaust Emissions toxicity means the combined toxicity of the several constituents of diesel exhaust as defined by the Exhaust Quality Index (EQI) equations of clause 3.5.4.1 in this standard.

Exhaust treatment device means a device designed to remove or reduce the concentrations of one or more of the constituents defined in EQI equation. Odour, aldehydes and other constituents not defined in the EQI may also be affected.

Fuel alteration means modification of 'normal' fuel to accomplish a reduction in emissions of one or more constituents in the exhaust, such as by emulsifying water into the fuel oil to reduce nitric oxide (NO) generation or adding additives to reduce soot ignition temperature in particulate traps.

2.3 **Other technical terms**

Air Compressors are devices which pressurize the working medium (air) for storage in a pressure vessel.

Diesel engine means a compression-ignition, internal combustion engine that utilizes a low-volatile hydrocarbon (diesel) fuel (see clause 4.9).

Fire resistant hydraulic fluid is a fluid which is fire-resistant to the extent defined for category 2 in CSA Standard CAN3-M423-M84.

Grade means the slope of an incline expressed as a per cent. For example, a rise of 20 m in a length of 100 m is a 20% grade. This corresponds to an angle of inclination of 11.3°.

Hydraulic Systems are defined as consisting of hydraulic fluid, a hydraulic power source, a reservoir, controls, actuators or motors, together with interconnecting conduits and accessories which are used to mechanize function of a vehicle.

Safety Shutdown System refers to the system which, in response to signals from various systems on the machine, indicates the existence of a safety hazard, and may automatically stop the engine and the vehicle.

2.4 **Administrative terms**

Certifying Agency means the testing and certifying organization (eg. Canadian Explosive Atmospheres Laboratory) acceptable to the Regulatory Authorities.

Regulatory Authority is the organization responsible for mine safety in a given jurisdiction (eg. provincial or federal mining inspectorates).

3. Vehicle Performance Requirements

3.1 General

This standard refers to the following publications. The year dates shown indicate the latest issue available at the time of printing:

CSA Standards

1. C22.1-1982
   Canadian Electrical Code - Part 1;
2. CAN 3-M421-M85
   Use of Electricity in Mines:
3. C22.2 No. 30-M1984
   Explosion-Proof Enclosures for Use in Class I Hazardous Locations;
4. C22.1 No. 145
   Explosion - Proof Motors and Generators for Use in Class I and Class II Hazardous Locations;
5. C22.2 No. 152-1976
   Combustible Gas Detection Instruments
6. C22.2 No. 157-M1979
   Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations;
7. M422 (in preparation)
   Fire Retardant and Anti-Static Conveyor Belts;
8. CAN 3-M423-M1984
   Fire Resistant Hydraulic Fluids;
9. B352-M1980
   Rollover Protective Structures (ROPS) for Agricultural, Construction, Earth Moving, Forestry, Industrial and Mining Machines;
10. B351-M1981
    Code for Construction and Inspection of Boilers and Pressure Vessels.

Canadian General Standards Board Specification

11. CGSB CAN 2-3.16-M86
    Mining Diesel Fuel.

International Electrotechnical Commission Standard

12. IEC Publication 79-1,
    Electrical Apparatus for Explosive Gas Atmospheres.

International Standards Organization

13. ISO 1813-1976(E)
    Anti-Static Endless V-Belts (Sections Y, Z, A, B, C, D and E) - Electrical Conductivity - Characteristics and Method of Test;
14. ISO 3471-1980(E)
    Earth Moving Machinery Roll Over Protective Structures - Laboratory Tests and Performance Requirements.

Society of Automotive Engineers (SAE)

15. J10
    Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements;
16. J53
    Minimum Performance Criteria for Emergency Steering of Earth-Moving Construction Machinery;
17. J154a
    Operator Enclosures - Human Factor Design Consideration;
18. J209
    Instrument Face Design and Location for Industrial Equipment;
19. J231
    Minimum Performance Criteria for Falling Object Protective Structures (FOPS);
20. J386
    Seat Belts for Construction Machines;
21. J598
    Sealed Lighting Units for Construction and Industrial Machinery;
22. J899
    Operator's Seat Dimensions for Off-Road Self-Propelled Work Machines;
23. J994 September 1980
    Alarm - Backup - Electric - Performance, Test and Application;
24. J1040C
    Performance Criteria for Roll Over Protective Structures (ROPS) for Construction, Earth Moving, Forestry and Mining;

25. J1104 September 1980

Horn - Forward Warning - Electric - Performance, Test and Application;

26. J1446

On-Machine Alarm Test and Evaluation Procedure for Construction and General Purpose Industrial Machinery.

3.2 Industrial Safety Requirements

In general, vulnerable parts and systems, which constitute potential safety hazards, shall be constructed, positioned and protected as required to minimize the possibility of damage.

3.2.1 Lighting

3.2.1.1

The electrical system associated with vehicle lighting must meet the requirements specified in the Electrical equipment clause 3.3.2.

3.2.1.2

Each vehicle shall be equipped with two or more clear lighting units, each circuit protected against overload and short circuit by a device located close to the power source, permanently attached and directed to illuminate the roadway in the direction of travel. Each lighting unit shall produce illumination equivalent to but not less than that provided by a 60 watt incandescent sealed lighting unit as described in SAE Standard J598 "Sealed Lighting Units for Construction and Industrial Machinery".

3.2.1.3

Each bi-directional vehicle shall be equipped in accordance with clause 3.2.1.2 at both ends of the vehicle

3.2.1.4

Red or amber reflective, non-light alloy material (as defined in clause 3.3.1.3), shall be attached to both ends of each vehicle. The minimum area of red or amber reflective non-light alloy material attached to each end of a vehicle shall be 460 cm^2 (70 in^2).

Note: The mine operator or appropriate Regulatory Authority may require that additional tail lamps, and additional lighting required for illumination of a workplace while the vehicle is stationary, be provided.

3.2.2 Hydraulic and pneumatic systems

3.2.2.1

All hydraulic systems with the exception of those listed in clause 3.2.2.2 shall conform to the following clauses: 3.4.1 Surface temperature limitations, and 3.4.2 Use of fire-resistant hydraulic fluids.

Note: All Canadian Regulatory Authorities encourage the use of fire resistant hydraulic fluids, with a view to ultimately requiring maximum use on underground machinery.

3.2.2.2

Hydraulic systems and components presently excluded from the fire resistant hydraulic fluid requirements of clause 3.4.2 are as follows:

a) engine-related hydraulic systems such as hydraulic valve lifters, hydraulic cooling fan drives, lubricating systems and fuel injection systems;

b) torque converters;

c) transmissions;

d) axles;

e) braking systems employing totally enclosed friction elements immersed in a liquid coolant;

f) braking systems whose hydraulics are independent of any other hydraulic system;

g) steering systems having liquid capacities containing less than two litres.

3.2.2.3

The hydraulic filler cap shall be clearly and distinctively marked to differentiate it from any other filler cap so as to minimize the possibility of inadvertent introduction of an incorrect fluid.

3.2.2.4

Pneumatic systems, including air compressors, shall conform to the following clauses:

a) 3.2.4.2 Table 1 item (i) air compressor discharge temperature;

b) 3.3.9 air compressors
c) 3.4.1 surface temperature limitation.

Note: The above clause is not intended to apply to devices which pressurize the inlet air to the engine.

3.2.2.5
The pressure vessel shall comply with the requirements of CSA Standard B51-M 1981, "Code for the Construction and Inspection of Boilers and Pressure Vessels" and SAE J10 "Automotive and Off-Highway Air Brake Reservoir Performance and Identification Requirements", as applicable. Pressure vessels greater than 152 mm in diameter and of a volume larger than 0.0425 m^3 shall comply with CSA Standard B51. Pressure vessels with a diameter equal to or less than 152 mm or a volume equal to or less than 0.0425 m^3 shall comply with SAE J10.

3.2.2.6
Pressure vessels shall be constructed and located or protected so as to be capable of safely resisting damage in a vehicle collision.

3.2.3 **Fuel system**

3.2.3.1
Fuel tanks shall be of substantial construction and securely mounted in such a position as to be reasonably secure against accidental damage or damage resulting from a collision.

3.2.3.2
The total fuel capacity of the vehicle shall not exceed that required for eight hours or one full shift of full load engine operation, which ever is longer.

3.2.3.3
Each fuel tank shall be tested by the manufacturer to be water-tight at 30 kPa gauge (4.35 psig).

3.2.3.4

Fuel tank vent openings and filler caps shall be provided to maintain atmospheric pressure within the tank and minimize leakage of fuel. These shall be located remotely from hot surfaces and permanently attached to the vehicle to prevent loss.

3.2.3.5

Fuel lines between the tank and the engine shall be constructed of fire-resistant material (see clause 4.7.3.2) and shall be routed and supported so as to avoid hot engine surfaces and moving parts and to afford a maximum of mechanical protection.

Note: . Fuel transfer and injections pumps are referred to in clauses 3.2.5.2, 3.2.5.3 and 3.2.5.4.

3.2.4 Driver's control station, controls and instruments - vehicle mounted for vehicle control

3.2.4.1

The driver's control station shall be equipped with a driver's seat which reduces the transfer of vehicle frame movement, and a seat belt conforming to SAE Standard 386 "Seat Belts For Construction Machines".

Note: Guidance regarding the minimum dimensions for each seat and of the space provided for the occupant shall be derived from the appropriate SAE Standard for the type of underground vehicle involved. Refer to SAE J899 "Operator's Seat Dimensions For Off-Road Self-Propelled Work Machines", and SAE J154a "Operator Enclosures Human Factor Design Considerations."

3.2.4.2

Instruments, audible warning alarms and visible warning alarms shall be provided to indicate to the driver unsafe conditions including, as a minimum, but not necessarily limited to those in Table 1:

Table 1 - Instrument, warning and shutdown requirements

Item	Instrument	Visible warning	Audible warning	Connection to safety shut-down system
a) safety shutdown system				
-pressure system	required	not required	not required	required
-electronic system	required	not required	not required	required
b) service brake reservoir pressure(s), including hydrostatic braking system	required	*1	*1	not required
c) secondary brake	*3	*2	*2	*3
d) application of parking brake (see clause 3.2.7.4.d) below)	not required	required	not required	not required
e) engine coolant temp	required	required	not required	required
f) torque converter outlet fluid temp	required	required	required if fire resistant fluid not used	required
g) independently-cooled retarder system temp	required	required	required if fire resistant fluid not used	required if fire resistant fluid not used
h) excessive exhaust temp and/or loss of water in exhaust system	not required	required	required	required
i) air compressor discharge temp	not required	required	not required	required
j) methane monitoring system	required	required	not required	required
k) flexible bellows (see note for clause 3.3.6)	not required	not required	not required	required

*1 one or the other required for each braking circuit (see clause 3.2.7.2c).
*2 one or the other required if automatically applied secondary brake system is supplied. The warning shall preceed brake application (see clause 3.2.7.3.c).
*3 required if automatically applied secondary brake system is supplied.

Note: The above table is part of a three step approach to safe operation: indication, warning, and shutdown - (see clause 3.2.8 below). The extent of the requirement is determined by the perceived degree of hazard in each case.

3.2.4.3

All instruments required by clause 3.2.4.2 shall be displayed in accordance with SAE Standard J209 "Instrument Face Design and Location for Construction and Industrial Equipment".

3.2.4.4 **Protective structures**

Vehicles covered by this standard are intended to be operated only in mines whose openings have been regularly inspected and made safe, and to be operated on roadways or in openings considered adequate for safe operation. Notwithstanding this intention, all vehicles shall be equipped with substantially constructed canopies located and installed in such a manner that when the operator is at the operating controls of such equipment he shall be protected from falls of roof (Falling Object Protective Structure - FOPS). A canopy shall be considered to be substantially constructed if a registered professional engineer certifies that the structure has a minimum capacity to support elastically: (1) a dead weight point load of 8,200 kg (18,000 lb), or (2) 100 kPa (15 psi) distributed over the plan view area, whichever is the lesser, or, if constructed in accordance with SAE J231 "Minimum Performance Criteria for Falling Object Protective Structure (FOPS)".

Note: In cases of mines which, because of particular conditions, offer hazards of unstable ground, steep roadways, unusual loading or dumping arrangements, etc., the mine operator or the appropriate Regulatory Authority may require that special protection, in addition to FOPS, be attached to and become part of a vehicle covered by this standard, such as a Rollover Protective Structure (ROPS).

3.2.4.5

The performance criteria for Rollover Protective Structure (ROPS) where specified, shall be in accordance with CSA Standard B352-M 1980, "Rollover Protective Structures (ROPS) for Agricultural, Construction, Earth Moving, Forestry, Industrial and Mining Machines", or SAE J1040c "Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earth Moving, Forestry and Mining", or ISO 3471-1980E "Earth Moving Machinery Rollover Protective Structures - Laboratory Tests and Performance Requirements".

3.2.4.6

The performance criteria for Tipover Protective Structures (TOPS) when specified, shall be designed in accordance with the requirements for ROPS as in clause 3.2.4.5.

3.2.4.7

Each FOPS, ROPS, or TOPS shall be permanently marked showing:

a) the manufacturer's name and address;

b) the model number; and

c) the make and model number of the vehicle which it is designed to fit.

3.2.5 **Engine and drive**

3.2.5.1

The engine construction shall conform to the flameproof requirements outlined in Clause 3.3.5.

3.2.5.2

If the engine fuel system incorporates adjustable components which control the fuel flow rate to the combustion chambers and/or the maximum engine RPM, then such adjustments shall be made so that the engine will perform within the emission limits specified in clause 3.5.1. The adjustment shall only be made by a qualified fuel injection specialist. On completion the element(s) by which the adjustment is made, shall be sealed with a wire and lead seal. The governor/injection system shall function so that the air flow is not directly affected.

3.2.5.3

The maximum fuel rate shall be limited by the emission requirements described in clause 3.5.1.

3.2.5.4

The certified maximum fuel injection rate at sea level, and the certified high idle range RPM shall be stamped on a plate permanently attached to the pump or governor housing. Changes to the data stamped on the plate shall only be made on the approval of the Certifying Agency. A second plate shall be permanently

attached to the pump or governor housing on which a lesser or greater allowable fuel injection rate shall be stamped, when appropriate, so as to conform to an altitude correction or special ventilation requirement stipulated by the appropriate Regulatory Authority.

3.2.5.5
The fuel employed in certification tests shall conform to the appropriate CGSB (Canadian General Specification Board) Specification CAN 2-3.16 - M83, "Mining Diesel Fuel".

3.2.5.6
The maximum rated output shall be that which the engine delivers at the maximum allowable fuel injection rate and rated speed when operating with the complete engine air intake system and the engine exhaust system specified in clauses 3.3.4 and 3.3.6 below.

3.2.5.7
The sample engine submitted for approval shall be tested on a dynamometer as described in clause 4.9 and shall conform to the requirements described therein.

3.2.6 Emergency steering - wheeled vehicles

3.2.6.1
Where a vehicle depends on power for steering, and the loss of such power prevents the vehicle from being steered manually, an emergency steering system conforming to SAE J53 "Minimum Performance Criteria for Emergency Steering of Wheeled Earth Moving Construction Machinery", shall be installed.

3.2.6.2
Where an auxiliary hydraulic pump is used to provide the emergency steering capability, the hydraulic fluid supplied to the pump shall be taken from a separate reservoir, or from an isolated section of the main reservoir.

3.2.6.3
Where stored energy systems provide the emergency steering capability, means shall be provided to de-energize the systems after a time delay from engine shut down.

3.2.7 Braking systems

Each vehicle having a fully-loaded mass of 45,000 kg (100,000 lb) or less, shall have a braking system capable of stopping the vehicle from a maximum speed of 32 km/h (20 mph) on a minus 20% grade unless otherwise specified on the grade certification plate (see clause 3.2.7.5 below). The braking systems shall include service, secondary (or emergency), and parking systems each defined as follows:

Service Braking System - The primary system of any type used for stopping and holding the machine. It shall be of the totally enclosed liquid cooled type.

Secondary Braking System - The system used for stopping the machine in the event of any single failure in the service braking system.

Parking System - The system used to hold a stopped machine stationary.

3.2.7.1 Common components

The above parking system may use common components. However, a failure of a common component shall not reduce the effectiveness of the stopping capability of the machine below the secondary braking performance.

3.2.7.2 Service braking system performance

a) Stopping Performance - The service braking system, when tested in accordance with clause 4.3.4, shall stop the machine within the distance specified in Table 2, in both directions of travel if applicable.

b) System Recovery - With the machine stationary, the primary power source of the service braking system shall have the capability of delivering at least 70% of maximum brake pressure measured at the brakes when the brakes are fully applied 12 times at the rate of 4 applications per minute with engine operating at low idle speed.

c) Warning Device - Service braking systems using stored energy to apply braking force shall be equipped with a warning device which actuates before system energy drops below 50% of the manufacturer's specified maximum energy level, or before the energy level required to meet the secondary braking system stopping distances specified in Table 2 is reached, whichever is greater. The device shall be readily visible and/or audible to the operator and provide a continuous warning. Gauges indicating pressure or vacuum shall not be acceptable to meet these warning requirements.

Note: Clause 3.2.7.2(c) does not apply to braking systems where stored energy is used to release the applied braking force, such as in a spring-applied, air-released braking system.

d) The maximum allowable effort to actuate the service braking system shall be 700 N (160 lb) for a foot-operated system and 400 N (90 lb) for a hand-operated system.

e) The inherent braking effect of a hydrostatic drive system is acceptable as the service brake system provided that the creep speed, with the drive control in the neutral position when descending the maximum design grade (20% unless otherwise stated), shall not exceed 10 m/min (0.37 mph).

f) The service braking system shall have the capability to hold the stopped vehicle stationary on the reference grade of 20%, while the operator is applying the brake.

g) Vehicles fitted with multiple hydraulic braking circuits shall have a device to warn the operator of failure in any one hydraulic circuit (see Table 1 item b).

3.2.7.3 **Secondary braking system performance**

a) Stopping Performance - The secondary braking system, when tested in accordance with clause 4.3.5, shall stop the machine within the distance specified in Table 2, in both directions of travel if applicable.

b) Manual Application - The secondary braking system shall be capable of being applied by a person seated in the operator's seat. The system shall be arranged so that it cannot be released from the operator's seat after any application unless immediate reapplication can be made from the operator's seat to stop the vehicle.

c) Automatic Application - In addition to manual control, the secondary braking system may also be applied automatically. If an automatically applied secondary braking system is used, the application shall occur after the warning device is actuated.

d) The maximum allowable effort to actuate the secondary braking system shall be 700 N (160 lb) for a foot operated system and 400 N (90 lb) for a hand operated system.

3.2.7.4 Parking system performance

a) Holding Performance - The parking system shall have the capability equivalent to holding the machine stationary on a 20% grade, or on a grade 5% more than the maximum rated operating grade specified on the grade certification plate required in clause 3.2.7.5 whichever is greater, under all conditions of loading specified by the manufacturer.

b) System Application - The parking system shall be capable of being applied by a person sitting in the operator's seat. The system shall be arranged so that it cannot be released from the operator's seat after any application unless immediate reapplication can be made from the operator's seat.

c) Remain Applied - The parking system while applied shall maintain the parking performance in compliance with clause 3.2.7.4a despite any contraction of the brake parts or change of temperature of system parts, exhaustion of the source of energy or leakage of any kind.

d) Parking brake system application shall be indicated by a visible warning signal which shall be obvious to the operator (see 3.2.4.3 item d).

3.2.7.5 Grade certification plate

All vehicles shall be fitted with a durable and permanently affixed plate on which are indelibly recorded the year of manufacture, the name of the manufacturer, the serial number and model number, the rated gross mass, and the maximum grade the vehicle may be operated on.

3.2.8 Safety shutdown system - diesel engine

3.2.8.1

Each vehicle shall be equipped with a safety shutdown system which shuts down the engine in response to signals received from sensors located as follows:

a) Within the engine and exhaust coolant system, at the point of the highest coolant temperature before it returns to the radiator. The safe shutdown temperature shall be established by the engine manufacturer.

b) In the gas stream of the exhaust system. The shutdown actuation temperature may be up to 8°C (14°F) above the operating temperature requirement of clause 3.3.6(d), 77 + 8 = 85°C (185°F).

c) In the exhaust gas conditioner to register low water levels when necessary, as defined by consultation between the manufacturers and the Certifying Agency in order to minimize the number of scrubber temperature monitoring points.
d) A methanometer shall be installed which shall provide a visible warning to the operator at a 0.75% methane concentration. The safety shutdown system shall be actuated at a 1.25% methane concentration. The performance of the methane monitoring system shall conform to the provisions of CSA Standard C22.2 No. 152-1976 "Combustible Gas Detection Instruments".

Note: Some Regulatory Authorities may require other warning and shutdown methane threshold concentrations.

e) In the torque converter fluid discharge. The shutdown shall be actuated when the discharge fluid temperature reaches 150°C (300°F) or the maximum permissible temperature specified by the manufacturer, whichever is the lesser.

3.2.8.2
The combustion air shutoff valve, by which the engine may be shutdown for emergency purposes, shall ensure that the engine is not damaged and that internal combustion ceases within 30 seconds of initiation. Shutdown shall be effective even if combustible gas is ingested by the engine. See clause 3.3.4(e). Loss of control pressure shall result in closure of the valve resulting in automatic shutdown. The shutdown system shall also be operable manually from the control station.

3.2.8.3
In the case of non-flameproof flywheel housings, the safety system shall not permit engagement of the starting mechanism while the engine is running under its own power.

3.2.8.4
In cases where the lack of engine lube oil pressure must be overridden in order to start up, the override system shall not be capable of overriding any other shutdown function. The shutdown override shall require the sustained use of only hand/finger pressure.

3.2.9 Safety shutdown system - brakes

3.2.9.1

If an automatically applied secondary brake system is furnished, it shall be automatically actuated if the engine stops, stalls or is shutdown by the safety shutdown system because of unsafe circumstances defined in Table 1 and clause 3.2.8.1.

3.2.10 Vehicle movement-alarms

Forward warning and backup alarms shall be fitted to vehicles when required by the appropriate regulatory authority. When fitted, these devices shall conform to the specifications of SAE J994 Sept 80 "Alarm-Back-Up-Electric-Performance, Test and Application", and SAE J1105 Sept 80 "Horn-Forward Warning-Electric-Performance, Test and Application", and SAE J1446 "On-Machine Alarm Test and Evaluation Procedure for Construction and General Purpose Industrial Machinery".

3.3 Explosion-proof (flameproof) requirements

3.3.1 Safe gaps and joints

Interfaces between adjacent parts of explosion-proof (flameproof) components are categorized as follows and shall conform to the corresponding standard shown:

Description	Standard
(i) Simple flanged interfaces	CSA C22.2 No. 30 "Explosion-Proof Enclosures for use in Hazardous Locations".
(ii) Venting devices e.g., plate type flame arrestors	IEC Publication 79-1 "Electrical Apparatus for Explosive Gas Atmospheres".

3.3.1.1

Threaded fasteners associated with the interfaces described in 3.3.1 shall conform to the appropriate standard listed in the table above and shall, in addition, be so constructed that when installed as stated by the manufacturer, loosening of the fastener will not occur.

Note: Some Regulatory Authorities may require that bolts or nuts securing joints which do not require frequent attention (such as those securing joints in the exhaust system) are to be fastened in a fashion which will enhance the security of the flameproof joint in service such as wire locks or bent-tab washers. Such joints include all intake and exhaust system joints except:

a) flame trap joints (for which lock washers are acceptable);

b) scrubber filler plug;

c) scrubber drain plug;

d) others subject to the judgement of the Certifying Agency.

3.3.1.2 Restricted use of aluminum and aluminum alloys

The use of aluminum and aluminum alloys, excluding the use of aluminum as an alloying agent in the manufacture of steel and bronze, is restricted as follows. Aluminum or aluminum alloys shall not be used for decals or information plates nor in paint, nor in exposed external parts, unless no other suitable substitute can be found, in which case the part shall meet two of the three following conditions:

a) The material is sprayed with a zinc coating 0.1 mm (0.004") to 0.15 mm (0.006") thick.

b) The part is located in a non-impact area.

c) The part is protected by an impact deflection baffle or guard.

3.3.1.3

Alloy materials not meeting the required conditions in clause 3.3.1.2 may be used providing the following composition restrictions are satisfied:

a) Aluminum plus titanium plus magnesium in any combination shall not exceed 15% of the total metal by mass in the alloy.

b) Titanium plus magnesium shall not exceed 6% of the total metal by mass in the alloy.

3.3.2 Electrical equipment

3.3.2.1 Electrical components

Electrical components shall be either enclosed in flameproof enclosures conforming with CSA Standard C22.2, No. 30 "Explosion-Proof Enclosures for Use in Class I Hazardous Locations", or No. 145, "Explosion Proof Motors and Generators for use in Class I and Class II Hazardous Locations", (as applicable) or shall be intrinsically safe in accordance with CSA Standard C22.2,

No. 157, "Intrinsically Safe and Non-Incendive Equipment for use in Hazardous Locations". Combustible gas detection instruments shall conform to CSA Standard C22.2, No. 152, "Combustible Gas Detection Instruments".

3.3.2.2 Interconnecting wiring

Wiring between components shall be either run in fire-resistant hose conduit or shall be in fire-resistant shielded portable trailing cable complying with the trailing cable requirements of CSA Standard C22.5 "Use of Electricity in Mines". Hose conduit shall have a minimum wall thickness of 4.8 mm (3/16") and shall be capable of passing the test for fire resistance given in clause 4.7.3.2 below. Wiring shall be routed in the manner most likely to protect it from contact with sharp objects and from accidental damage. Cable glands and terminations shall comply with the requirements for the enclosures which they enter (e.g., flameproof).

3.3.2.3 Protection and control

All ungrounded conductors shall be provided with suitable overcurrent devices for the purpose of automatically opening the electrical circuit in the event of dangerous overload or a short-circuit. Such control, where practicable, shall meet the requirements of CSA Standard C22.1 "Canadian Electrical Code, Part I". Where the source of electrical power is external to the machine, such protection may be provided external to the machine.

3.3.3 Starting system

3.3.3.1

The engine starter system may be powered by any means excluding combustion systems.

Note: Some jurisdictions may exclude electric start.

3.3.3.2

Steel starter pinions shall only be used if the engagement mechanism cannot apply more than 20 kg.m (150 ft lbf) of impact energy; beryllium copper pinions shall only be used if the engagement impact energy is limited to a maximum of 48 kg.m (350 ft lbf). Alternatively, any starter pinion material may be used but the flywheel housing, in which the starter pinion and ring gear

are located, shall conform to the flameproof requirements in clauses 3.3.1 above and 3.3.5.4 below.

3.3.4 Engine intake system

The engine intake system shall:

a) Convey combustion air to the engine. The connecting ducting from the arrester to the manifold shall be sized so that the air velocity at lowest idle engine rotational speed is a minimum of 3 m/s (10 fps) in order to reduce the possibility of flame stabilization on the arrester and the consequent dangerous increase in the temperature of the arrester elements and other adjacent equipment.

b) Prevent transmission of internal engine combustion to a surrounding explosive atmosphere in accordance with the flameproof requirements of clauses 3.3.1 and 4.6.1.

c) Have a maximum surface temperature of 150°C (300°F) at sustained full engine load.

d) Filter the engine intake air in accordance with the engine manufacturer's recommendations.

e) Be provided with a combustion air shutoff valve between the intake air filter and the intake flame arrester, in order to permit emergency engine shutdown (see clause 3.2.8.2).

3.3.5 Engine requirements

The engine shall be manufactured in accordance with the provisions of clauses 3.3.5.1 to 3.3.5.4 as follows:

3.3.5.1

Normal diesel engine design, the design of fastenings associated with the joints in this clause, and normal manufacturing tolerances and wear limits provide acceptable flameproof barriers for the joint clearances between:

a) pistons and piston rings;

b) pistons and cylinder walls;

c) piston rings and cylinder walls;

d) cylinder head to cylinder block;

e) valve stem to valve guide;

f) injector body to cylinder head.

Any joints other than those listed above which directly or indirectly connect the combustion chamber to the surrounding atmosphere must be flameproof in accordance with clause 3.3.1 above.

3.3.5.2

The engine crankcase breather shall not contain filtering materials composed of aluminum, magnesium or titanium and shall not be connected to the air intake system of the engine. The discharge from the breather shall be directed away from hot surfaces and in such a way as to ensure that the external surfaces of the engine and exhaust system do not become fouled with oil.

3.3.5.3

The oil filler and oil dipstick shall be secured in position by positive means which do not rely solely on friction and which prevent loss of oil from the interior of the engine.

3.3.5.4

The engine flywheel, clutch and starter ring gear housing must be flameproof as described above in clause 3.3.3 unless clutch and starter impact energies are below the maximum values stated therein.

3.3.6 **Engine exhaust system**

The engine exhaust system shall:

a) Convey the products of combustion away from the engine.

b) Prevent transmission of internal engine combustion and incandescent sparks to a surrounding explosive atmosphere in accordance with the flameproof requirements of clauses 3.3.1 and 4.6.1. Flameproof exhaust system components not complying with all the provisions of clause 4.6.1 shall be subject to special requirements (see note below).

c) Have a maximum surface temperature at sustained full engine load of 150°C (300°F).

d) Cool the exhaust gas leaving the last treatment device and before mixing with mine air in the vehicle's dilution system to a temperature of no more than 77°C (170°F) for a half shift period (3 hours of vehicle operation) automatically and without intervention by the operator or other personnel (see clause 4.1).

e) Dilute the exhaust gas to fulfill the requirements of clause 3.5.5.
f) Be resistant to corrosion, especially in areas where flameproof integrity may be affected, (such as gasketed joints).

Note: A flexible bellows assembly may not meet all the requirements of clause 3.3.1 and 4.6.1 but shall be permitted provided that its failure initiates shutdown of the engine automatically by being constructed so that it is double-walled with the annulus liquid cooled or that it is double walled with annulus pressurized by air or inert gas where loss of liquid or pressure respectively shall initiate an automatic engine shutdown.

3.3.7 Brake and clutch

3.3.7.1 Dry type brakes and clutches

To maintain the component parts of non-liquid cooled secondary or parking brake and clutch systems at acceptably low temperatures (below the ignition temperature of methane/air mixtures in the range from 650 to 750°C) the following criteria, expressed as ratios of maximum power dissipation to brake or clutch surface area, shall apply:
a) "Enclosed" shoe/drum/clutch plate system where enclosed infers inhibited cooling - 0.20 kw/cm^2 (1.7 BHP/in^2).
b) "open" caliper/disc/clutch plate systems where open infers uninhibited cooling - 0.40 kw/cm^2 (3.5 BHP/in^2). Brake and clutch linings must be of a type to minimize incendive sparking by frictional contact and the brake or clutch system design must ensure that the brake or clutch linings are prevented from unintentional contact with rotating parts when not in braking or engaged clutching position.

3.3.7.2 Totally enclosed liquid cooled brakes

The surface temperature of the housing of totally enclosed liquid cooled brakes shall not exceed 150°C (300°F).

3.3.8 Anti-static materials

Anti-static materials shall be used whenever the use of a static-producing material would generate hazardous levels of electrical energy as defined in testing clause 4.6.3.1. Anti-static materials shall be used for, but not

limited to, conveyor belts, V-belts, and plastic cooling fans. All materials shall be tested in accordance with the requirements of clause 4.6.3.

3.3.9 Air compressors

3.3.9.1
Air compressors shall be liquid cooled (see clause 3.2.2.5a).

3.3.9.2
Air compressors with a lubrication fluid supply independent of the engine lub-oil system, shall utilize a fire resistant fluid.

3.3.9.3
Air compressor intake air shall not be drawn from a location downstream of the air intake flame arrester.

3.4 Fire prevention requirements

3.4.1 Surface temperature limitations

The external surface temperature of all vehicle components shall not exceed 150°C (300°F) under any test condition, (see clause 4.7.2). Exterior surfaces shall be designed to minimize accumulation of dust and combustible material and facilitate removal of same.

3.4.2 Fire resistant hydraulic fluids

The resistance to fire of the fluids used in hydraulic systems shall be in accordance with CSA Standard CAN3-M423-M84 "Fire Resistant Hydraulic Fluids", category 2.

3.4.3 Fire resistant materials

Wherever fire resistant materials can be obtained and perform adequately they shall be employed in the manufacture of flameproof machines. Such materials shall be used for, but not limited to hoses, wire insulation, conveyor belts and V-belts. All such materials shall be tested in accordance with the requirements described in section 4.7.3.

3.4.4 Mechanical protection

Mechanical protection shall be provided for fuel lines and other parts which contain flammable fluids.

3.4.5 Fire suppression

3.4.5.1 Hand-held fire extinguishers

One or more approved multi-purpose hand-held fire extinguisher(s) suitable for class A, B, and C fires, shall be fitted to each diesel vehicle. They shall be readily accessible from the operator's compartment and conform to the following minimum requirements:

Vehicle power rating		Fire extinguisher type A, B, C normal capacity	
kw	(BHP)	kg	(lb)
0 - 75	(50 - 100)	4.5	(10)
75 - 110	(100 - 150)	9	(20)
110 plus	(150 plus)	9*	(20)*

*Additional equipment required; refer to following clause 3.4.5.2.

3.4.5.2 Installed multi-nozzle fire supression system

Vehicles rated at more than 110 kW shall be fitted with a fire suppression system which can be operator-activated but which shall also operate automatically in the event of fire. Manual activation of the installed multi-nozzle fire suppression system shall be possible by actuation of easily accessible ground level devices from each side of the machine and at the operator's station. Where the actuator at the operator's station is readily accessible from ground level it will be sufficient to install one other actuator on the opposite side of the machine, also accessible from ground level.

3.4.5.3 Extinguisher system checks

The effectiveness of the multi-nozzle fire extinguisher system shall be determined by documentation, by test, or both.

3.5 Exhaust emissions requirements

3.5.1 Fuel rate setting

The liquid fuel supply to the new engine shall be adjusted, fixed and sealed so that the undiluted exhaust gas shall contain not more than 2500 ppm of carbon monoxide, not more than 1500 ppm of oxides of nitrogen (NO_x) and not more than 150 mg/m^3 of particulate (as measured by a centre line sampling probe), within the full design range of engine output, when the intake air mixture to the engine is either 100% air, or 1.25% methane by volume in air. Reduction in the maximum allowable fuel injection rate for increases in altitude above 300 m (approximately 1,000 ft) shall be made.

3.5.2 Fuel alteration system

Fuel alteration innovations which are practicable and are shown to beneficially affect the emissions, shall be permitted.

3.5.3 Exhaust treatment devices

Exhaust treatment may be accomplished by a number of devices; for example, filters and water scrubbers, applied singly or in combination. Where evidence can be furnished that treatment performance does not deteriorate with use and that suitable procedures can be instituted to maintain the device(s), their application shall result in reduced ventilation assessments as defined in clause 3.5.4.2 below. The emissions reduction performance of all such devices shall be assessed during dynanometer exhaust emissions tests as described in clause 4.9.

3.5.4 Emissions toxicity criterion

3.5.4.1

In order to establish the Exhaust Quality Index, (EQI) for undiluted exhaust emitted from the diesel engine and the last treatment device, the concentration of the various pollutants contained in the exhaust shall be considered additive in accordance with the following expression:

$$EQI = \frac{(CO)}{50} + \frac{(NO)}{25} + \frac{(RCD)}{2}$$

$$+ 1.5 \quad \frac{(SO_2)}{3} + \frac{(RCD)}{2}$$

$$+ 1.2 \quad \frac{(NO_2)}{3} + \frac{(RCD)}{2}$$

where: EQI = Exhaust Quality Index
(CO) = carbon monoxide concentration (ppm)
(NO) = nitric oxide concentration (ppm)
(RCD) = respirable combustible dust concentration (mg/m^3)
(SO_2) = sulphur dioxide concentration (ppm)
(NO_2) = nitrogen dioxide concentration (ppm)

3.5.4.2
Ventilation air requirement shall be based on a dilution ratio of (EQI/3) where 3 is the maximum value of the ambient mine Air Quality Index (AQI) in accordance with the calculation prescribed in clause 4.10.

Note: 1. AQI max = 3 and dilution ratio = (EQI)/(AQI max).
2. Limit values used in the denominators of the EQI expression shall not be adjusted when changes to the ACGIH-TLVS are made.

3.5.4.3
In circumstances where unusually low amounts of diesel particulates are emitted from the machine, it may be that the concentration of one or more of the gaseous emissions will exceed the current ACGIH-TLV. In such cases, sufficient ventilating air shall be provided to ensure that the concentration of each toxic constituent, taken separately, does not exceed its current ACGIH-TLV, or other appropriate limit, at its maximum rate of generation.

3.5.5 **Exhaust dilution system**
A dilution system shall reduce the undiluted toxic exhaust constituents emitted from the last treatment device, such as a water scrubber, to levels equivalent to an average AQI of 3 (maximum excursion of 4) in the operator's cab or

passenger compartment if applicable. Exhaust dilution may be accomplished by a number of devices such as exhaust flow induced air entrainment, injection into radiator ejection air flow, mechanical baffling, emission point location, etc. No exhaust constituent designated as having a "C" (Ceiling) rating should exceed that rating at the operator's breathing zone, or passenger's breathing zone, if applicable.

4. Vehicle performance tests

4.1 Exhaust system cooling capacity evaluation

Tests on the sample of equipment submitted to the Certifying Agency shall be undertaken to determine directly by dynamometer tests or indirectly by engineering calculations, the capacity of the exhaust system to continuously cool the exhaust gases to 77°C (170°F) for a half-shift period (3 hours of vehicle operation) see clause 3.3.6(d).

Note: Vehicle load factor studies have been reported (1983) in Canada, Sweden and the USA. A maximum vehicle load factor of 0.85 relative to full load, full speed operation is reported for a heavily-loaded Load-Haul-Dump machine. Some haulage trucks exhibit a load factor of 0.70, whereas, utility vehicles and personnel carriers may operate at a 0.50 level load factor. These rules of thumb shall be used to evaluate the cooling capacity of scrubbing systems and may be used by the appropriate Regulatory Authority to reduce ventilation rates (see clause 4.10) according to vehicle type, assuming individual concentrations of toxic constituents remain below their respective current TLVs (see clause 3.5.4.3).

4.2 Safety shutdown system operation confirmation

The operation of all safety shutdown devices on a completed vehicle shall be checked against the performance requirements of this standard during factory or field inspection.

4.2.1 Methanometer tests

The performance of the methanometer system shall be tested according to the provisions of CSA Standard C22.2 No. 152 "Combustible Gas Detection Instruments".

4.3 Braking systems tests

4.3.1 Facilities required

The service braking system, secondary braking system, and parking system test course shall consist of a hard, dry surface with a well-compacted base not exceeding 2% rolling resistance. The test surface shall not exceed 3% grade at right angles to the direction of travel. The approach to the test course shall be of sufficient length, smoothness and uniformity of slope to ensure stabilized travel speed of the machine before the brakes are applied.

4.3.1.1 Test grades

Vehicles Designed to Operate on Grades of 20% or Less - The test surface for the service braking system and secondary braking system shall have a uniform downgrade slope of 20% ± 1.

Vehicles Designed to Operate on Grades Greater than 20% - The test surface for the service braking system and secondary braking system shall have a uniform downgrade slope as specified on the Grade Certification Plate required in clause 3.2.7.5.

All Vehicles - The test surface for the parking system shall have a uniform slope equivalent to the grade holding capability specified in paragraph 3.2.7.4(a).

4.3.2 Instrumentation

Instrumentation shall be employed to make the following measurements:

Measurement	Measurement resolution
a) vehicle stopping distance	±1%
b) vehicle velocity	±3%
c) vehicle mass	±3%
d) braking system(s) energy level	±3%
e) force required by the operator to actuate the braking system(s)	±3%

4.3.3 Test requirements

4.3.3.1
The braking systems as installed on the machine shall be burnished and adjusted to the manufacturer's specifications.

4.3.3.2
The test weight of the machine shall be the manufacturer's maximum recommended loaded weight for such a machine.

4.3.3.3
Tires shall comply with the machine manufacturer's specifications.

4.3.3.4
The stopping distance shall be measured from the point of actuation of the brake system to the point at which the machine stops.

4.3.3.5
The stopping test shall be conducted at the maximum rated speed of the test machine on which the braking system is installed.

4.3.3.6
Auxiliary retarders shall not be used during the service braking system tests. Auxiliary retarders may be used during the secondary braking system tests provided that a single component failure does not render both the retarder and a portion of the braking system inoperative; i.e., retarder circuits and brake system circuits must be separate and independent. If these conditions are not met, the retarder shall not be used during the secondary braking system tests.

4.3.3.7
When the machine transmission provides a selection of gear ratios, the stopping tests shall be carried out with the transmission in the gear suitable for the test speed specified. The power train may be disengaged prior to completing the stop.

4.3.4 Test procedure - Service braking system

4.3.4.1

Prepare and drive the test machine over the test course in accordance with paragraphs 4.3.1, 4.3.2 and 4.3.3 and apply the service brakes with the vehicle on the slope specified in clause 4.3.1.1.

4.3.4.2

Record the maximum force to actuate the service braking system. This force shall be in accordance with Section 3.2.7.2(d).

4.3.4.3

Record the stopping distance.

4.3.4.4

The prescribed test procedures shall be repeated a minimum of five times in succession without change or adjustment of the braking system and at intervals not to exceed five minutes between each test.

4.3.4.5

The stopping capability of the service braking system shall be the average of the five tests in accordance with Section 3.2.7.2(a). No single stop shall exceed 1.13 times the stopping distance shown in Table 2 for the appropriate speed.

4.3.5 **Test procedure - Secondary braking system**

4.3.5.1

The secondary braking system test procedure shall be identical to that described in clause 4.3.4 for the service braking system with the exception of clauses 4.3.5.2 and 4.3.5.3 below.

4.3.5.2

The prescribed test procedures shall be repeated a minimum of three times in succession without change or adjustment of the braking system.

4.3.5.3

The stopping capability of the secondary braking system shall be the average of the three tests shall be in accordance with Section 3.2.7.3(a). No single stop shall exceed 1.13 times the stopping distance shown in Table 2 for the appropriate speed.

4.3.6 Test Procedure - Parking system

4.3.6.1

The parking system shall be tested by stopping the machine on a grade at least 5% steeper than the rating of the machine. The vehicle engine shall then be shut off. Repeat the test with the vehicle in the opposite direction. The test surface condition shall be in accordance with paragraph 4.3.1.

4.3.6.2

The parking system shall prevent machine movement, excluding drive train slack, in either direction.

4.4 Fuel tank leak check

Fuel tanks shall be tested by the manufacturer in accordance with clause 3.2.3.3.

4.5 Headlight intensity check

The headlight intensity shall be assessed in accordance with the requirements of clause 3.2.1.

4.6 Explosion prevention tests on engine systems

4.6.1 Explosion proof enclosure tests

Refer to CSA Standard C22.2 No. 30 "Explosion Proof Enclosures for Use in Class I Hazardous Locations", and IEC Publication 79-1 "Electrical Apparatus for Explosive Gas Atmospheres", as applicable, for flameproofness and over-pressure tests and for structural adequacy of explosion proof enclosures. Explosion tests shall be required in accordance with the appropriate document (see clause 3.3.1).

4.6.2 Impact tests on coated aluminum alloy parts

External parts made from coated aluminum alloy materials shall be evaluated for frictional impact hazard on the basis of results obtained from drop tests and judgements made with respect to their intended application, (see clauses 3.3.1.2 and 3.3.1.3).

4.6.3 Anti-static materials tests

4.6.3.1 Anti-static rubber v-belt test

The method of ISO Standard 1813-1976 (E) "Anti-Static Endless V-Belts (sections Y, Z, A, B, C, D, E) - Electrical Conductivity - Characteristic and Method of Test" shall be used to "ensure that the belt is sufficiently conductive to dissipate charge of electricity which may form in it in service". This standard pertains to new belts intended to be used in an explosive atmosphere or in situations where there is a fire risk. This test shall be performed if no adequately documented tests in accordance with the standard have been previously performed, and show the material to be acceptable. The test values of resistance thus determined shall be less than the specified maxima as determined by the following relation:

$$R_{max} = 6 \times 10^5 \times \frac{L}{I} \text{ ohms}$$

where L is the distance between the inner edges of the two electrodes and where I is the sum of the heights of the two sidewalls of the belt.

4.6.3.2 Anti-static plastic engine cooling fans

CSA Standard C22.2 No. 145 "Explosion Proof Motors and Generators for Use in Class I and Class II Hazardous Locations", clause 2.3.3 states - "External rotating parts of non-metallic material shall be investigated for the generation of electrostatic charges if the resistance between the extreme ends of the part exceeds 10 megohms". The tip-to-tip and tip-to-hub resistances of the fan shall be determined. If the resistance exceeds 10 megohms the fan shall not be acceptable.

4.6.3.3

Conveyor belts shall be tested to CSA Standard M422, "Fire Retardant and Anti-Static Conveyor Belts" (under preparation).

4.7 Fire prevention tests

4.7.1 Fire resistant hydraulic fluid tests

Refer to CSA Standard M423, "Fire Resistant Hydraulic Fluids", categories 1 or 2.

4.7.2 Surface temperature checks:

Tests shall be carried out at various engine load/speed combinations with up to 1.25% methane in the intake air to determine the maximum external surface temperatures of the various vehicle components. The testing sequence shall also ensure that the vehicle safety devices prevent excessive surface temperatures in the event of:

a) shortage of liquid in the cooling circuits,

b) pneumatic or hydraulic system malfunctions, including hydraulic relief valves,

c) heat build-up in components upon application such as in service, emergency and parking brake systems; in torque converters particularly in a stalled condition; and in retarders,

d) any other malfunctions which could produce elevated external surface temperatures on one or more of the vehicle components.

The temperature test may be made at any room temperature between 10°C and 40°C. The 40°C value is assumed to be the maximum possible ambient temperature for which the corresponding surface temperatures must not exceed 150°C. The ambient temperature differential below 40°C shall be added to the observed surface temperatures before comparing with the value in clause 3.4.1.

4.7.3 Fire resistant materials tests

4.7.3.1 Conveyor belt tests

The conveyor belt tests and specifications are described in CSA Standard M422 "Fire-Retardant and Anti-Static Conveyor Belts" (under preparation).

4.7.3.2 Hose tests

The hose tests and specifications shall be similar to the tests described in CANMET, Division Report ERP/MRL 80-21(TR), clauses 4.1 to 4.5, except for test purposes, only 4 specimens of the hose (each 6 inches long by 1/2 inch wide by the specimen thickness) shall be required.

4.7.3.3 Other tests

Other fire-resistant materials, such as V-belts, will be tested in a manner similar to the tests described in clause 4.7.3.2.

4.8 Electrical systems tests

4.8.1 Explosion-proof enclosures tests

All tests of flameproof electrical enclosures shall conform to the provisions of Section 6 - "tests" of CSA Standard C22.2 No. 30 - 1970, "Explosion-Proof Enclosures for use in Class I Hazardous Locations". This document describes:

a) the maximum explosion pressure test,
b) explosion flame propagation test,
c) overpressure tests,
d) temperature tests,
e) impact tests (including glass lenses) and,
f) materials flammability tests.

4.8.2 Intrinsically safe systems tests

All tests of intrinsically safe electrical systems shall conform to the provisions of Section 6 - "Tests" of CSA Standard C22.2 No. 157 - M1979 "Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations".

4.8.3 Lighting system lens strength test

See clause 4.8.1 item d above.

4.8.4 Electric motor and generator tests

Electric motors and generators intended for hazardous location applications will be tested to CSA Standard C22.2 No. 145, "Explosion Proof Motors and Generators for Use in Class I and Class II Hazardous Locations".

4.9 Dynamometer emissions tests

One series of dynamometer emission tests on a single example of the specified power package shall be performed. The power package shall include all those systems which affect the levels of emitted toxic constituents.

Such tests shall include but not necessarily be limited to:

a) confirmation of the maximum fuel rate setting,

b) fuel alteration system performance evaluation if applicable,

c) determination of untreated engine emissions,

d) exhaust treatment device(s) performance evaluation if applicable,

e) exhaust dilution system performance evaluation.

Variations due to the addition of methane (CH_4) in the intake air shall be determined for items (a) (b) (c) and (d) above. The engine submitted for test shall be pre-run to the extent required to allow it to be operated immediately at full load and speed in an approved laboratory or test facility. Couplings or adapters for attachment of the engine to the testing laboratory dynamometer shall be furnished by the applicant. Clutches, transmissions or torque converters, are not generally required in the coupling train. The fuel employed for engine dynamometer Emission Tests shall conform to CGSB Specification CAN 2-3. 16-M86 "mining diesel fuel".

4.10 Assessed ventilation recommendations

The results of tests at the engine operating conditions which produce the greatest toxicity hazard, and as specified in clause 4.9 shall be employed in the following equation to assess the ventilation recommendation for untreated exhaust and for the exhaust leaving the last exhaust treatment device prior to exhaust dilution and emission into the environment:

$$Q_{dva} = \frac{M_{dxg} \times \frac{EQI}{3} + \frac{9H_2\%}{100} - 1 \quad M_f}{3600\ \delta} \qquad m^3/sec$$

where: Q_{dva} is the flow rate of dry ventilating air for the diesel machine in cubic metres per second.

EQI is the Exhaust Quality Index defined by clause 3.5.4.1.

M_{dxg} is the dry exhaust gas rate produced by combustion of the fuel in kg/hr.

M_f is the fuel consumption rate in kg/hr.

δ is the dry ventilation air density in kg/m^3.

H_2 is the per cent by weight of hydrogen in the fuel.

This level of ventilation will apply to all applications of the power package so tested. The above recommended ventilation rate pertains to the worst engine operating conditions from an emissions toxicity point of view, and therefore represents a maximum. Local conditions of altitude, methane concentration, vehicle loading cycle, multiple machine density, mine layout, etc., may reduce this ventilation recommendation as permitted by the appropriate Regulatory Authority. See note of clause 4.1 for ventilation reduction factors for various types of vehicle loading cycle.

Table 2A - Brake performance requirements (Customary units)

Machine speed mph	Maximum stopping distance, feet	
	Service brake	Secondary brake
6 and less	14.4	24.4
7	18.7	32.4
8	23.7	41.5
9	29.1	51.7
10	35.1	63
11	41.8	75.5
12	48.9	89
13	56.5	103.6
14	64.9	119.4
15	73.6	136.3
16	83	154.2
17	92.9	174.3
18	103.4	193.6
19	114.4	214.9
20	126	237.4

Notes: 1. All performance requirements are based upon an average deceleration of 0.12 g for service brakes and 0.06 g for secondary brakes.

2. Maximum stopping distances for both service brakes and secondary brakes include an allowance of 0.5 seconds for system delay time.

Table 2B - Brake performance requirements (SI units)

Machine speed	Maximum stopping distance, metres	
km/h	Service brake	Secondary brake
10 and less	4.7	8
11	5.5	9.5
12	6.4	11.2
13	7.4	14.7
14	8.3	14.7
15	9.4	16.8
16	10.6	19
17	11.8	21.3
18	13.1	23.7
19	14.5	26.3
20	15.9	29
21	17.4	31.9
22	19	34.9
23	20.5	37.8
24	22.2	41
25	23.9	44.4
26	25.8	47.9
27	27.6	51.5
28	29.6	55.3
29	31.6	59.2
30	33.7	63.3
31	35.9	67.4
32	37.9	71.4